

Cephalic index, facial index and dental parameters: A correlative study to evaluate their significance in facial reconstruction

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Abstract

Background: It becomes extremely challenging for forensic artists to reconstruct the highly decomposed faces, especially during mass disasters. It would be of great help for the identifying team of experts if there was a method to determine the facial and cephalic dimensions. This study aims to provide a method to generate a simplified method to calculate the facial and cephalic indices of an individual based on the dentition since human dentition remains almost intact in most scenarios.

Materials and Methods: The sample consisted of 200 participants with the age range of 18–23 years belonging to Kerala. The cephalic and facial indices were measured using a caliper. The interincisal, intercanine, interpremolar and intermolar widths of maxillary dentition were measured on study models using a digital vernier caliper. The mean cranial and facial index were calculated and were correlated with interdental measurements.

Results: It was concluded that dominant head types in Kerala males were dolichocephalic (50.2%) followed by mesocephalic (29.8%). In females, the dominant head types were dolichocephalic (42.7%) followed by mesocephalic (42.2%). In the facial types, majority of individuals were found to be leptoprosopic. A good correlation was found between the intercanine width with facial width and cranial width and a simplified formula were derived to estimate the cranial and facial index for this population.

Conclusion: The results of the study suggest that the facial index and cranial index of a particular population can be evaluated from interdental measurements of the maxillary cast, especially the intercanine width.

Keywords: Cephalic index, dental parameters, facial index, facial reconstruction, intercanine width, interincisal width, intermolar width, interpremolar width

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INTRODUCTION

Facial reconstruction is of paramount importance in the fields of forensic science and archaeology. In the forensic

context, it plays an important role in the identification of the dead where post-mortem deterioration has made it impossible for the forensic experts to identify the bodies.

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Forensic facial anthropology is the interpretation of human remains to attempt to depict the face of the individual.^[1]

Despite leaps in modern technology, medical breakthroughs and the geographical changes that the last century has brought, crime still persists in all aspects of our lives. Through the specialty of Forensic Odontology, dentistry plays a small but significant role in aiding the forensic experts in identifying the unidentified bodies thus assisting those involved in crime investigation.

The Indian subcontinent consists of varied ethnicity ranging from Kashmiris in the North to Dravidian race in the South and Northeast tribes of the Northeastern states to the Rajasthani people in the west. Therefore, applying the same constant foreign (Caucasian) values in calculating the facial index of the Indian population will result in false data.

In case of mass disasters such as earthquakes, floods or train accidents, many a time it becomes almost impossible to identify individuals due to disfigurement due to trauma or purification.^[2] Hence in such a scenario, the only reliable source of information can be achieved from the dentition and dental arches, as the tooth are the most hardest and stable tissue in the body.^[3] This study was undertaken to find out the relation between the dental arch dimensions with facial and cephalic measurements and thus try to be helpful in the final facial reconstruction of an individual.

MATERIALS AND METHODS

A group of 200 participants from the age group of 18 to 25 years was selected for the study. Participants originated originally from Kerala and were born and brought up in Kerala state, with no history of any previous orthodontic treatment and no dental abnormalities were considered for the study. The aims and objectives of the study were explained to the participants and informed consent was obtained at the beginning of the study.

All the landmarks were first identified, palpated and then marked lightly with pen before taking the measurements. The participant was asked to orient his head in the natural head position with Frankfort's horizontal plane being parallel to the floor. Participants were instructed to sit still while the measurements were being recorded.

To ensure accuracy and constancy in taking the measurements, all the measurements were recorded thrice following the techniques as prescribed by Martin and Saller.^[4]

Spreading caliper was used to measure the maximum head length from glabella to opisthocranium [Figure 1].

Transverse diameter between euryon to euryon gave the maximum head width which was measured using spreading caliper [Figure 2]. Morphological facial height, that is, the distance from nasion to gnathion [Figure 3] was measured using a sliding caliper and facial width [distance between two zygomatic landmarks - Figure 4] was measured using spreading caliper. Impression of the maxillary arch was taken and cast was prepared. Interincisal [Figure 5], intercanine [Figure 6], interpremolar [Figure 7] and intermolar [Figure 8] width were measured on these casts using a digital vernier caliper.

Method to calculate the cephalic and facial index

The shape of the skull can be noted using the cephalic index.

The Cephalic index was calculated using the equation given by Martin and Saller.^[4]

$$\text{Cephalic Index} = \text{Maximum Head width (eu-eu)} \times 100$$

$$\text{Maximum Head Length (ga-op)}$$

The facial index was calculated by the equation which was given by Williams *et al.*^[5]

$$\text{Facial Index} = \frac{\text{Morphological Facial Length (n-gn)} \times 100}{\text{Morphological Facial Width (zy-zy)}}$$

The collected data were subjected to statistical analysis. Pearson correlation test was performed to calculate the relationship of intraoral and extraoral landmarks with a series of regression equation. One way descriptive statistics was done to calculate the average mean of the cephalic and facial index for the Kerala population. To avoid the error of measurements, the intraexaminer reliability was calculated using the Spearmans correlation test between the 1st and 2nd measurements of the interincisal, intercanine, inter-premolar, inter-molar and the facial parameters, which resulted in an excellent correlation. $P < 0.05$ was used for statistical significance. A SPSS IBM software version-22 was used for statistical analysis.

RESULTS

The results of this study showed that the dominant head types in Kerala males and females were dolichocephalic (50.2% and 42.7%, respectively) followed by mesocephalic (29.8% and 42.2%).

The facial index and cephalic index of a particular population can be evaluated with the following equations from intradental measurements of the maxillary cast.



Figure 1: Measurement of maximum head length with the help of spreading caliper from glabella to opisthocranium

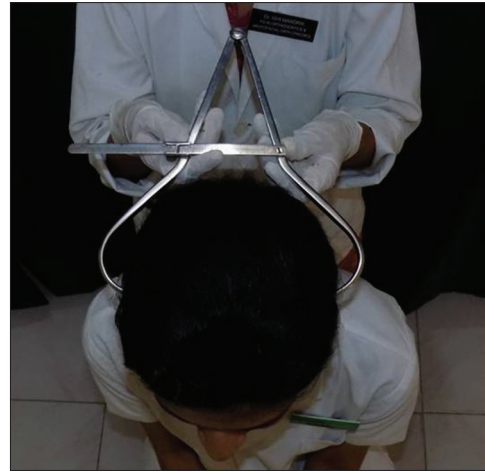


Figure 2: Measurement of maximum head width between euryon to euryon using spreading caliper



Figure 3: Measurement of morphological facial length-distance from nasion to gnathion measured using a sliding caliper



Figure 4: Measurement of facial width (distance between bizygomatic landmarks) measured using spreading caliper

Facial index was calculated based on the following equation

1. $120.813 - 0.05514 \times \text{Sum of Incisors}$
2. $123.803 - 0.5497 \times \text{Inter Canine width}$
3. $111.483 - 0.01695 \times \text{Inter Premolar width}$
4. $107.791 - 0.0663 \times \text{Inter Molar width.}$

Cephalic Index was calculated based on the following equation

1. $80.4480 - 0.23 \times \text{Sum of incisors}$
2. $78.4389 - 0.0560 \times \text{Inter Canine width}$
3. $82.1031 - 0.0433 \times \text{Inter premolar width}$
4. $81.9425 - 0.0340 \times \text{Inter Molar width.}$

The study showed a high significance between the intercanine width with cephalic and facial index ($P \leq 0.01$) using. A statistically significant relationship was exhibited between the interpremolar width and the facial index ($P \leq 0.05$). The same did not exist between intermolar and facial index

which means that the facial type and inter-molar width do not have good interrelationships.

Table 1 shows a good correlation between the inter-canine width and facial width. A significant correlation exists between the inter-premolar width and the facial index. The same does not exist between intermolar and facial index which means that the facial type and intermolar width have no good interrelationship.

Tables 2 and 3 show the comparative statistical inference of cephalic and facial indices between males and females.

DISCUSSION

In case of natural disasters identifying individuals becomes a challenging task for all those involved in rescue operations. According to Lain et al 2003 10% of the Tsunami and 50% of victims of the Bali bombing



Figure 5: Measurement of interincisal width using a digital vernier caliper



Figure 6: Measurement of intercanine width using a digital vernier caliper



Figure 7: Measurement of interpremolar width using a digital vernier caliper



Figure 8: Measurement of intermolar width using a digital vernier caliper

of October 12, 2002, were wrongly identified by facial recognition.^[6]

It becomes an obligation on part of the search and rescue teams to accurately identify the victims not only from a legal point of view but also for social and religious reasons. Since dentition remains intact in most scenarios, identification based on dental records is possible. However, the availability of antemortem records is questionable in India. The usual remains found in mass disasters are skull and the long bones. Most of the time, the only remnant available to the forensic team is the skull without the mandible. Since the maxillary dentition always remains intact in the skull, it offers itself to be a very reliable anatomical reference for human identification.

Since the Indian population has a wide ethnic diversity, same values cannot be applied universally. The average cephalic index seen in the South Indian Kerala population

varies from 78.76 ± 3.95 to 83.80 ± 3.385 . It can be compared with the studies done by Shah *et al.*, with a mean values of Cephalic index of 80.42, by Mahajan *et al.*, with a mean value of Cephalic index of 81.34, and by Anitha *et al.* with a mean cephalic index of 79.14.^[7-9] The average facial index in this study varies from 94.3 ± 7.2 to 106.9 ± 2.02 . It is significantly higher with the proposed values by Martin and Saller.^[5] It is higher than the value of 90.95 proposed by Doni *et al.*, 82.5 by Purkait in Ahiwar and Khurai block and 85.1 in Dangi and Khurai block of Madhya Pradesh, and a mean of 87.19 by Shetti *et al.* in a group of the Malaysian population.^[10-12]

This study showed a significant correlation between the intercanine width with the facial and cephalic index. A formula has been derived to calculate the facial index and cephalic index of a particular population, based on the dental parametric measurements and particularly the inter-canine width that was found to be the most reliable

Table 1: Correlations between anthropometric measurements and dental measurements

	Inter incisor	Inter canine	Inter premolar	Inter molar
Cephalic index				
Significance (two-tailed)	0.697	0.005	0.091	0.034
Facial index				
Significance (two-tailed)	0.090	0.001	0.015	0.203

Table 2: Comparative statistical inference of cephalic index-between males and females

Age	One-way descriptives			
	Mean±SD	95% CI for mean (lower bound-upper bound)	Minimum	Maximum
Cephalic index				
18.00	80.7962±3.40500	78.7385-82.8538	73.33	86.48
19.00	79.9285±4.13017	77.9955-81.8615	71.79	90.63
20.00	80.1028±3.60961	78.7788-81.4268	73.68	88.88
21.00	78.7491±3.85620	76.1585-81.3397	73.68	84.84
22.00	81.5567±4.54184	79.2981-83.8153	75.00	86.00
23.00	80.4307±4.40475	79.3956-81.4658	71.05	88.95
24.00	83.8033±3.38506	75.3944-92.2123	80.43	87.20
25.00	78.7633±3.95638	68.9351-88.5915	76.37	83.33
Facial index				
18.00	105.1708±5.10825	102.0839-108.2577	95.83	113.63
19.00	103.5560±7.84795	99.8830-107.2290	86.95	120.00
20.00	105.5958±8.06198	102.6386-108.5530	84.00	116.82
21.00	106.0555±8.61062	100.2708-111.8401	91.66	118.18
22.00	101.1444±6.39280	97.9654-104.3235	84.61	110.90
23.00	105.5019±7.42577	103.7570-107.2469	84.30	121.00
24.00	98.7700±14.41470	62.9619-134.5781	82.14	107.69
25.00	106.6400±2.39439	100.6920-112.5880	103.90	108.33

SD: Standard deviation, CI: Confidence interval

Table 3: Comparative statistical inference of facial index- between males and females

Cephalic index	Mean±SD	95% CI for mean (lower bound-upper bound)	Minimum	Maximum
18 male	80.8700±4.19160	77.3657-84.3743	73.33	86.48
18 female	80.6780±2.00174	78.1925-83.1635	77.77	82.85
19 male	78.1325±1.64242	75.5190-80.7460	75.67	79.02
19 female	80.3775±4.47129	77.9949-82.7601	71.79	90.63
20 male	80.3038±3.88267	78.6248-81.9828	73.68	88.88
20 female	79.0758±3.39213	77.4408-80.7107	73.68	85.71
21 male	81.3400±3.45068	50.3369-112.3431	78.90	83.78
21 female	81.5838±4.75162	79.0518-84.1157	75.00	96.00
22 male	79.4661±4.72778	77.6328-81.2993	71.05	87.43
22 female	81.0445±4.12421	79.7907-82.2984	71.05	88.95
23 male	79.1800±3.33613	73.8715-84.4885	76.37	83.33
23 female	85.4900±2.41831	63.7624-107.2176	83.78	87.20

SD: Standard deviation, CI: Confidence interval

parameter. Although this approach is still in its infancy, it can prove to be a valuable tool for individual identification related to a particular ethnic group. The formula derived in this study to estimate the craniometric measurements from the maxillary dental measurements is specific to the group of the South Indian Kerala population. Further extensive research needs to be carried out in various ethnic groups, thereby creating a large data bank to be used by the forensic experts.

The cephalic and facial index obtained in the study is significantly different from the values given by Martin and Saller which are being followed routinely. Therefore, the

results of this study will help the Indian forensic scientists to use the indigenous data in identifying the disaster victims more accurately.

CONCLUSION

The science of facial reconstruction has always been a challenging task for anatomists, artists and forensic experts. Decomposition of the human body is inevitable and the only available and reliable anatomical reference is the dentition and that too the maxillary arch. In this study, the intercanine dimension has proven itself to be a reliable reference to estimate the facial and cephalic dimensions of

an individual. Further detailed studies regarding the soft tissue overlay of individuals must be done on a much larger sample and ethnic groups. With the help of such data, the gender and ethnicity can also be estimated. This knowledge of the anthropological data of the ethnic population of Kerala will be of great help to forensic experts in accurately identifying the disaster victims.

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Conflicts of interest

There are no conflicts of interest.

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